



US009103419B2

(12) **United States Patent**  
**Cui et al.**

(10) **Patent No.:** **US 9,103,419 B2**  
(45) **Date of Patent:** **Aug. 11, 2015**

(54) **RADIALLY ENGAGING SYSTEM**

USPC ..... 74/22 R, 22 A, 23, 24, 48, 55, 813 L,  
74/567; 279/2.2, 2.19, 17, 135, 136;  
294/94

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See application file for complete search history.

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/535,490**

(22) Filed: **Nov. 7, 2014**

(65) **Prior Publication Data**

US 2015/0122060 A1 May 7, 2015

**Related U.S. Application Data**

(63) Continuation of application No. 14/073,589, filed on  
Nov. 6, 2013.

(51) **Int. Cl.**  
**F16H 25/18** (2006.01)  
**F16H 25/14** (2006.01)  
**F16H 21/50** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **F16H 25/14** (2013.01); **F16H 21/50**  
(2013.01)

(58) **Field of Classification Search**  
CPC . F16H 25/186; F16H 2059/081; F16H 27/02;  
F16H 53/02; F16H 37/16; F16K 5/162;  
F01B 1/0668; B23B 47/34; B23B 31/1207;  
B23B 31/101; B25D 16/00; B25D 17/084;  
H02K 15/085; E21B 1/02; Y10T 74/18296;  
Y10T 74/18312; Y10T 74/18024; Y10T  
74/18032; Y10T 74/1804; Y10T 74/18048;  
Y10T 74/1828; Y10T 74/1894

(56) **References Cited**

U.S. PATENT DOCUMENTS

488,960	A	12/1892	Brintnall	
3,158,017	A *	11/1964	Guze, Jr.	70/119
3,760,618	A *	9/1973	Wiczer	70/92
4,233,913	A *	11/1980	Herrmann	109/59 T
4,342,207	A *	8/1982	Holmes et al.	70/119
4,493,199	A *	1/1985	Uyeda	70/333 R
7,153,074	B2	12/2006	Wei	
8,123,428	B2 *	2/2012	Wareham	403/109.3
2006/0024148	A1	2/2006	Wei	

OTHER PUBLICATIONS

U.S. Appl. No. 14/073,589, filed Nov. 2013, Kan, Cui, 74/55.\*

\* cited by examiner

*Primary Examiner* — William Kelleher

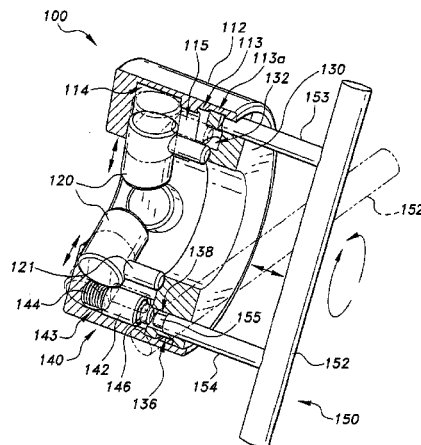
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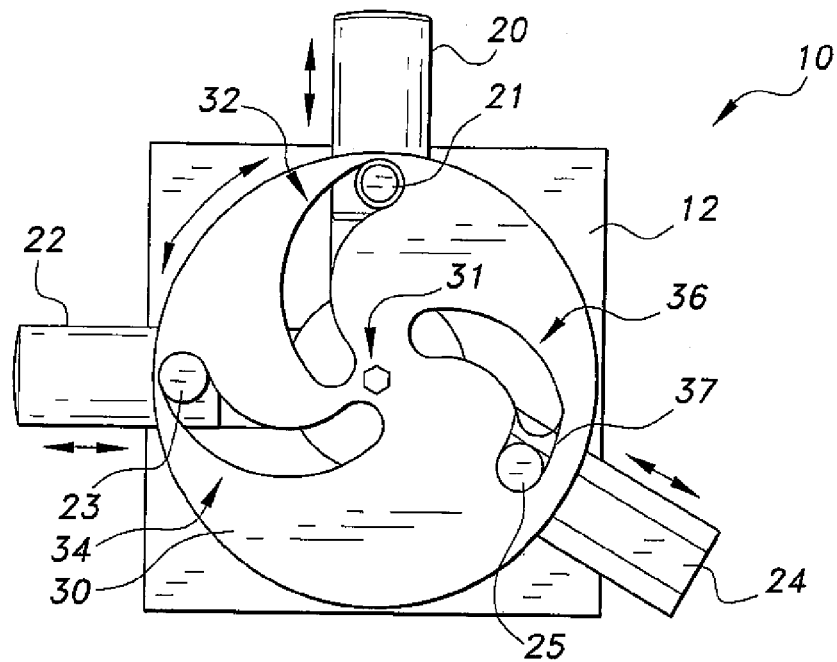
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(57) **ABSTRACT**

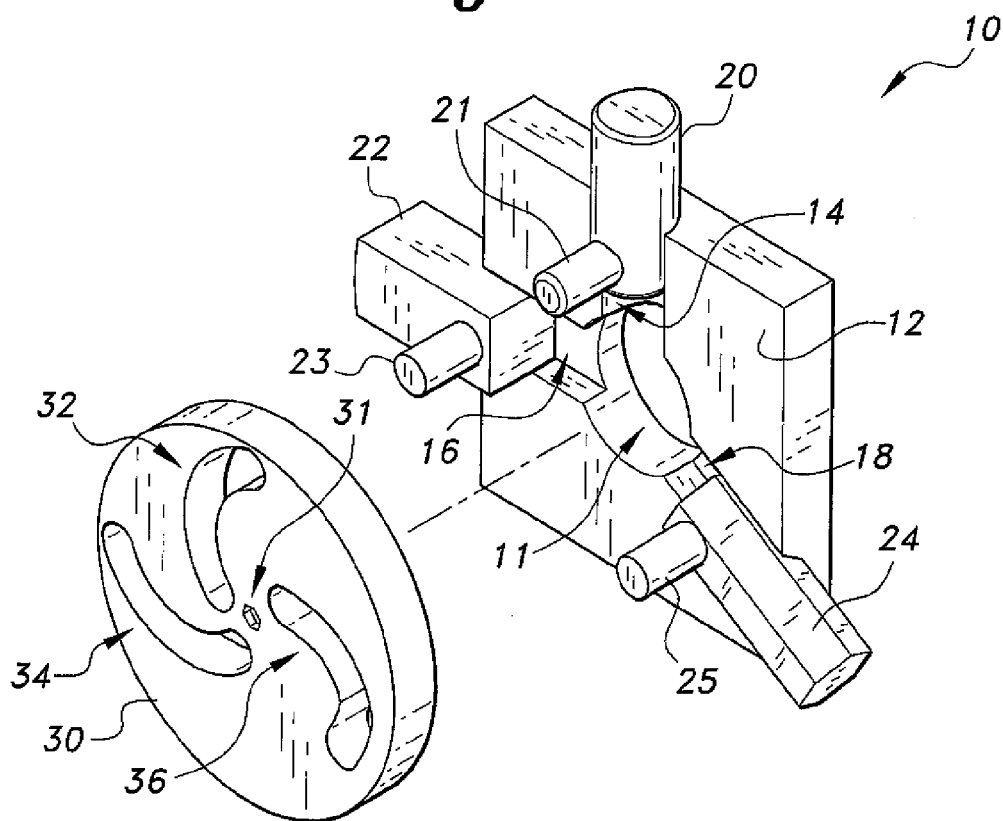
The radially engaging systems includes a housing having at least one guide channel formed therein. At least one sliding member is slidably received in the guide channel to selectively extend or retract therein in order to connect and lock mechanical components together. Each sliding member is provided with an elongate follower. A rotator is operatively mounted to the housing. The rotator includes at least one guide curve based upon an Archimedian spiral. The follower rides inside the guide curve. Selective rotation of the rotator converts the rotation into linear movement of the connected sliding member. Conversely, selective linear movement of the sliding member converts the same into rotation of the rotator.

**6 Claims, 11 Drawing Sheets**

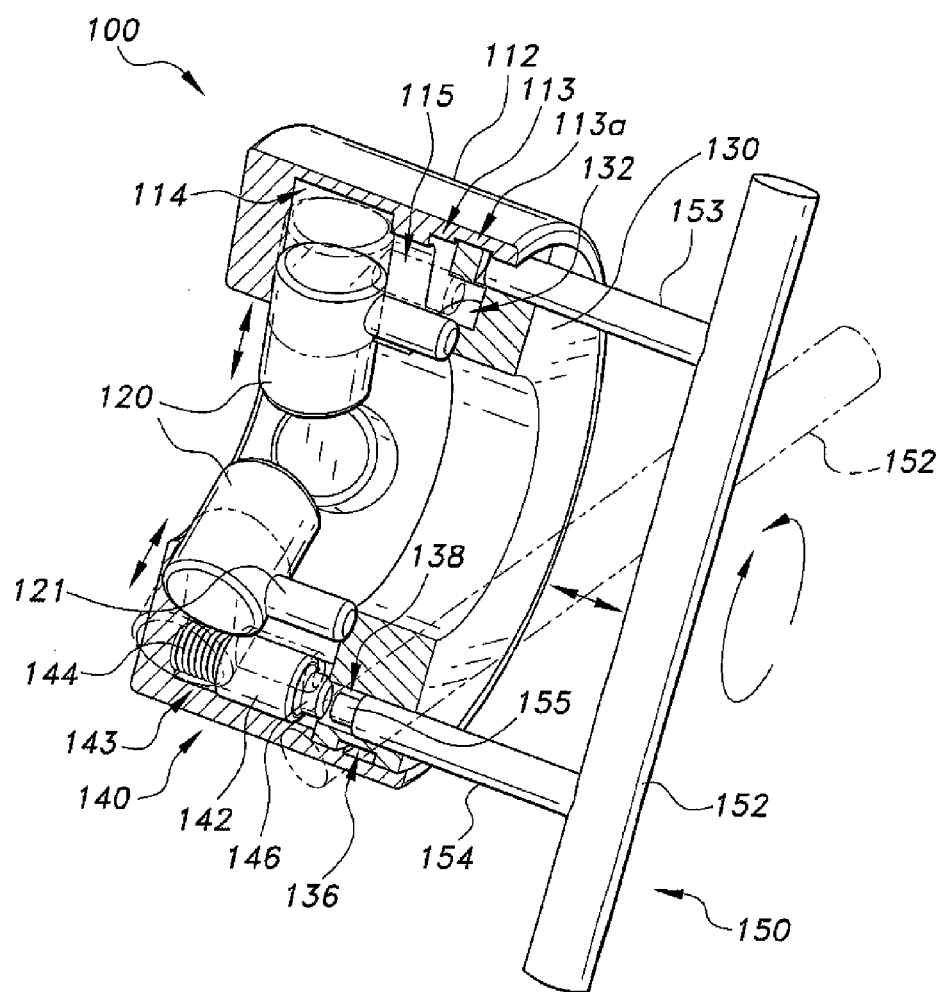




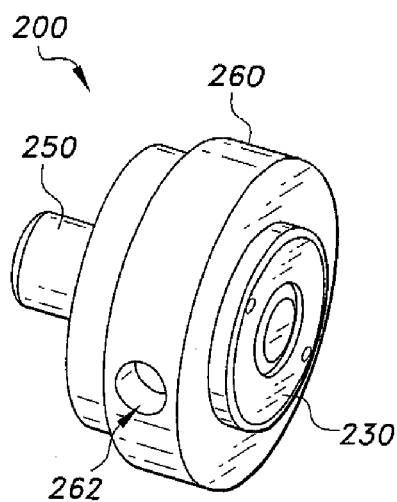
**Fig. 1A**



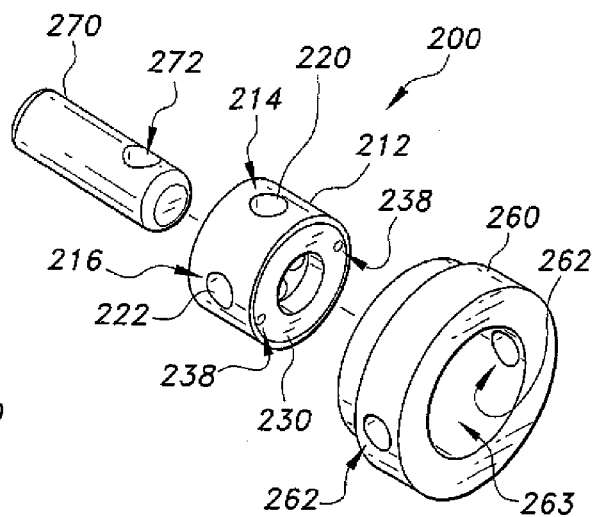
**Fig. 1B**



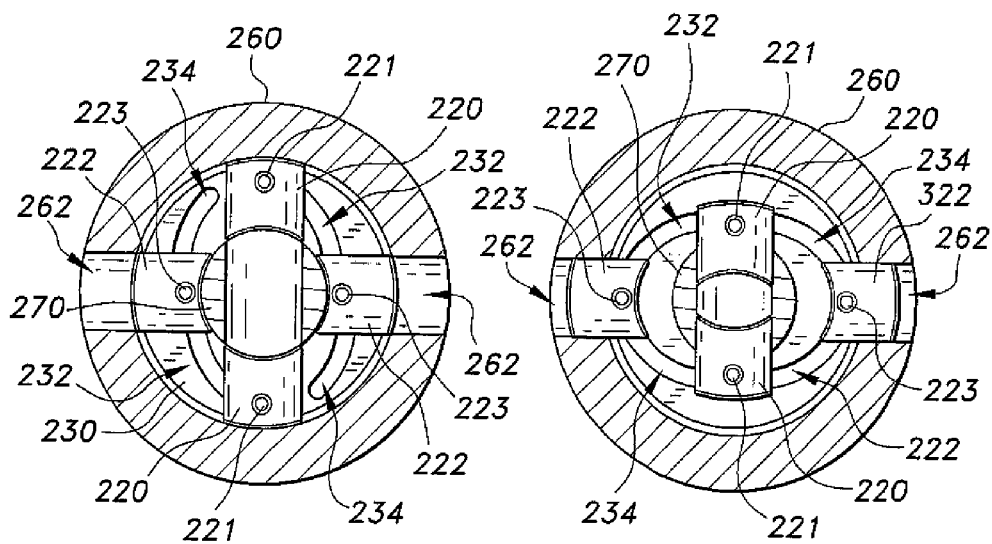
**Fig. 2**



**Fig. 3A**

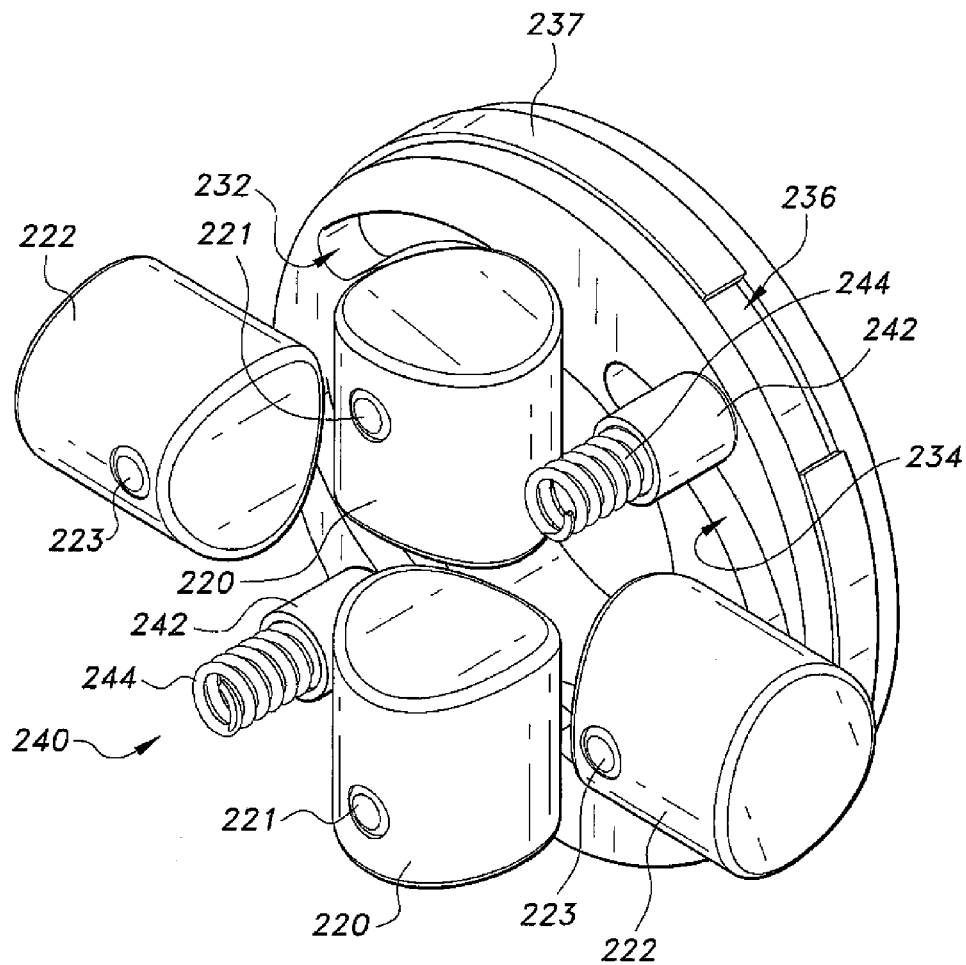


**Fig. 3B**

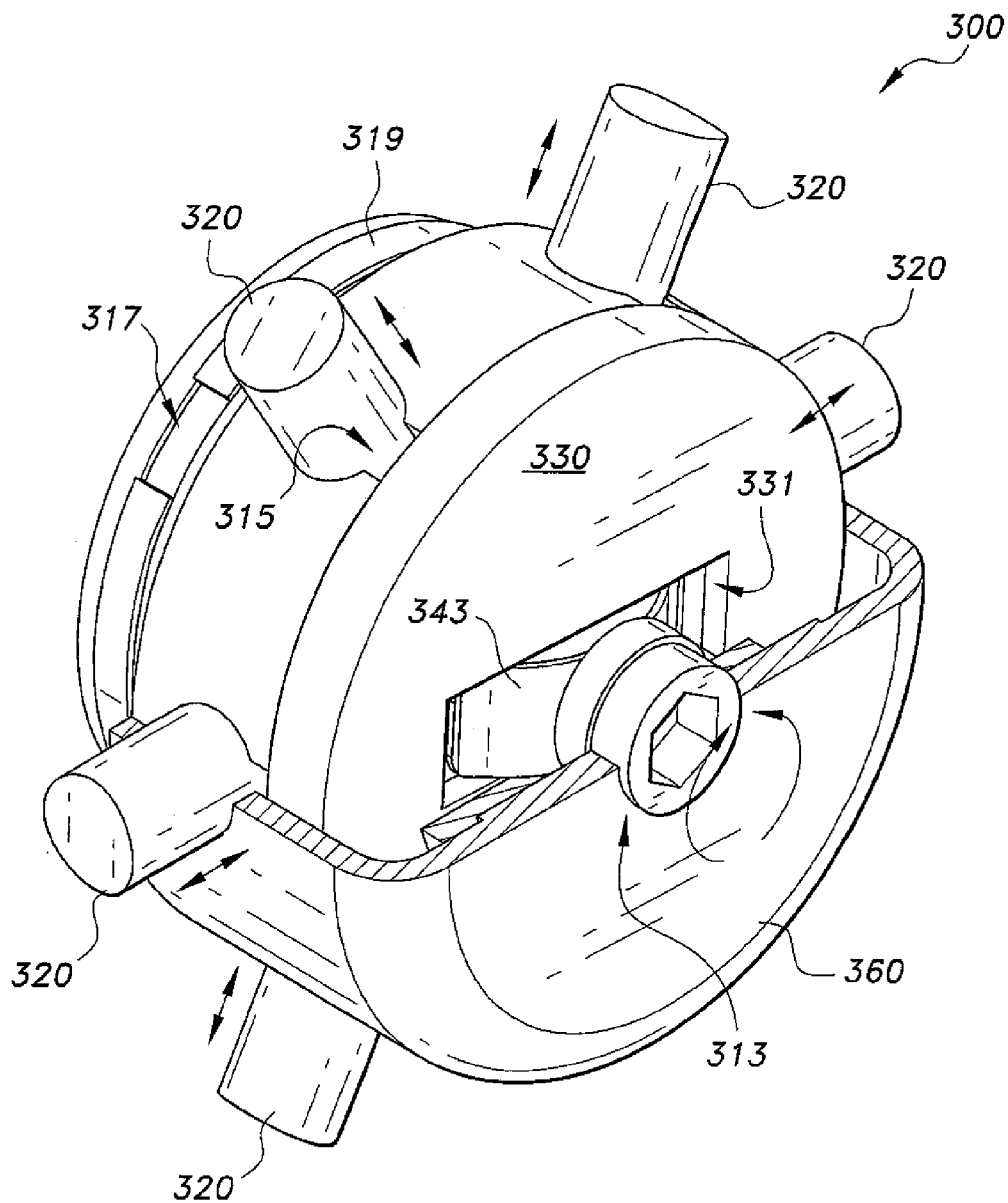


*Fig. 3C*

*Fig. 3D*



**Fig. 3E**



*Fig. 4A*

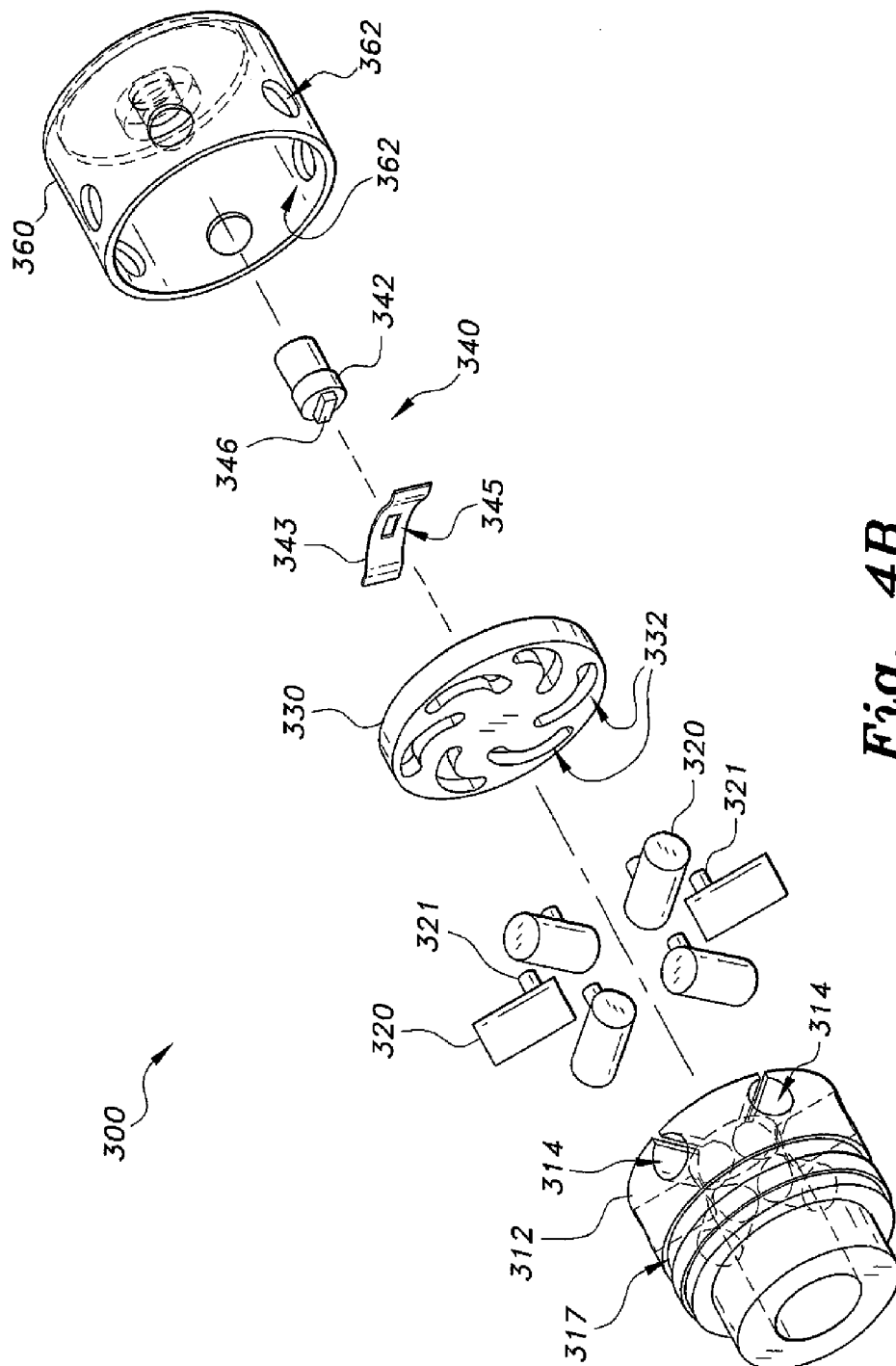
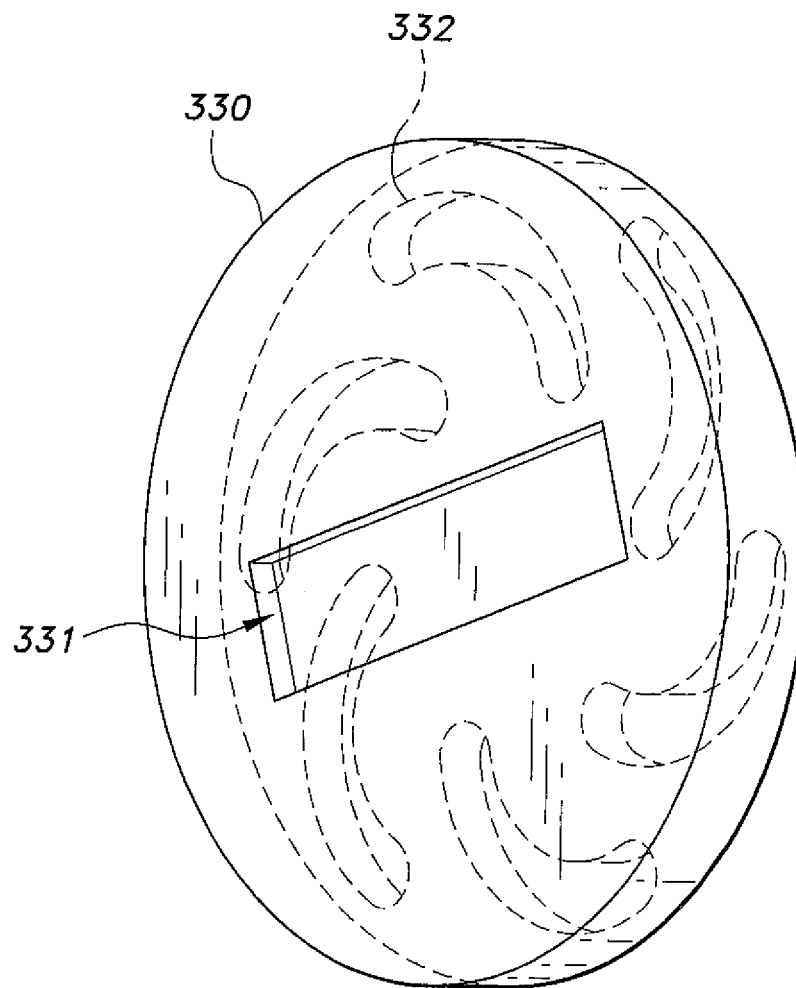
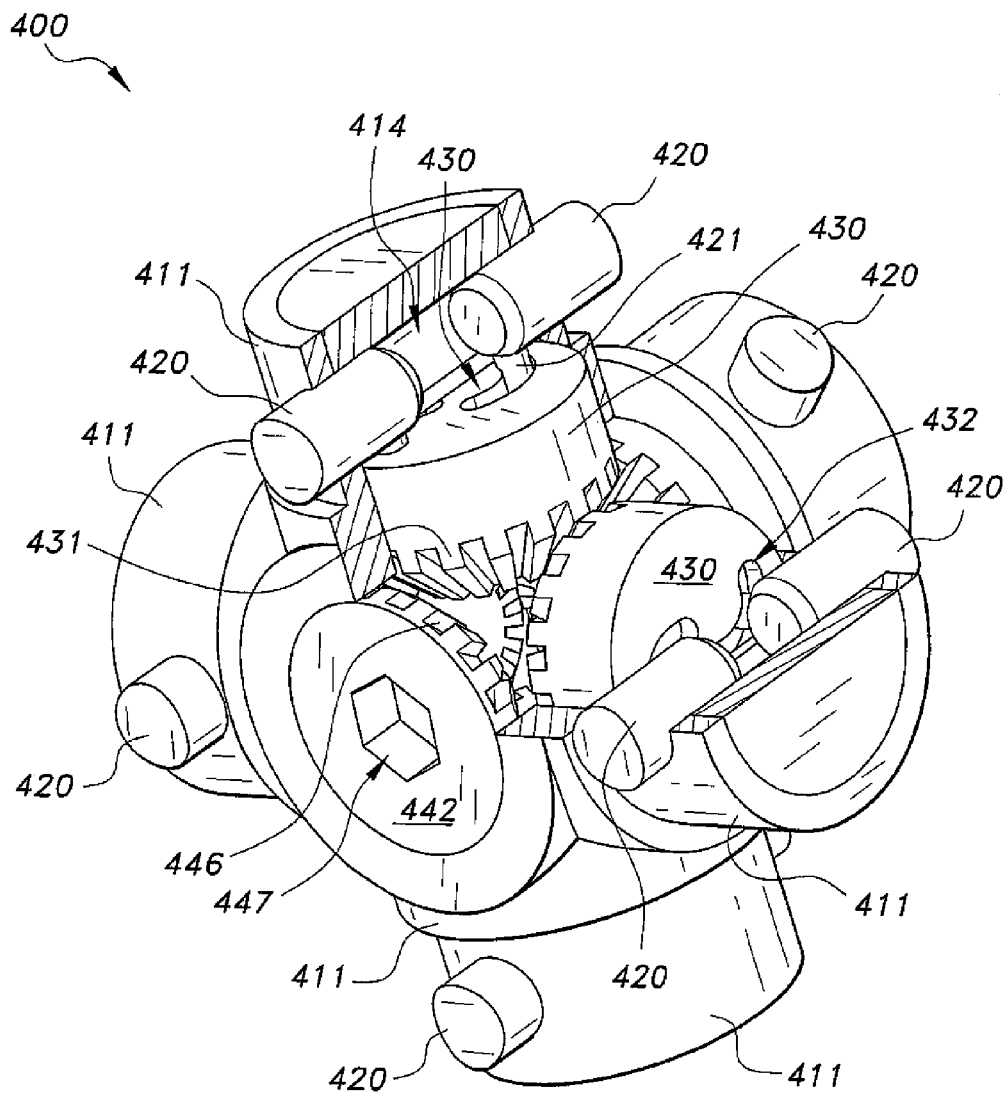


Fig. 4B

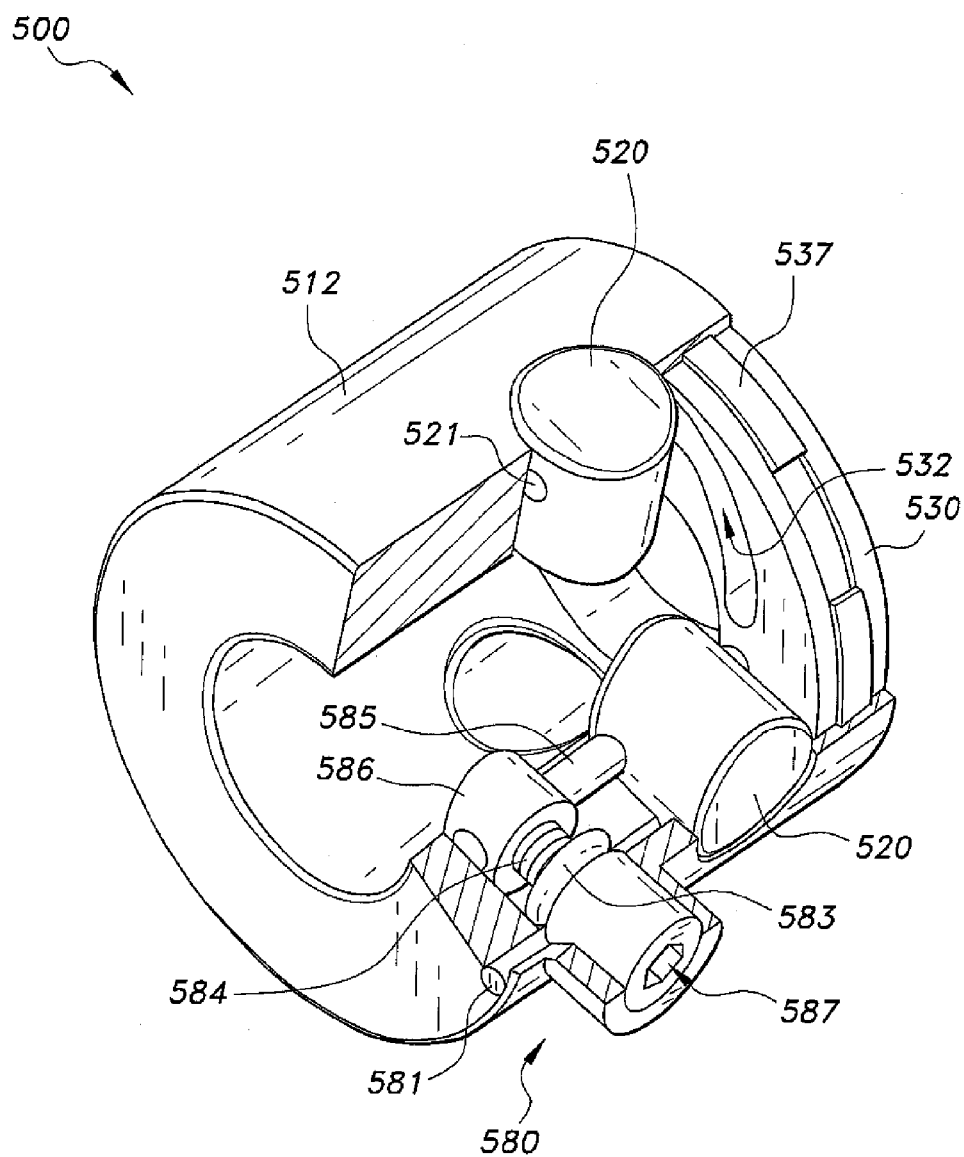


*Fig. 4C*

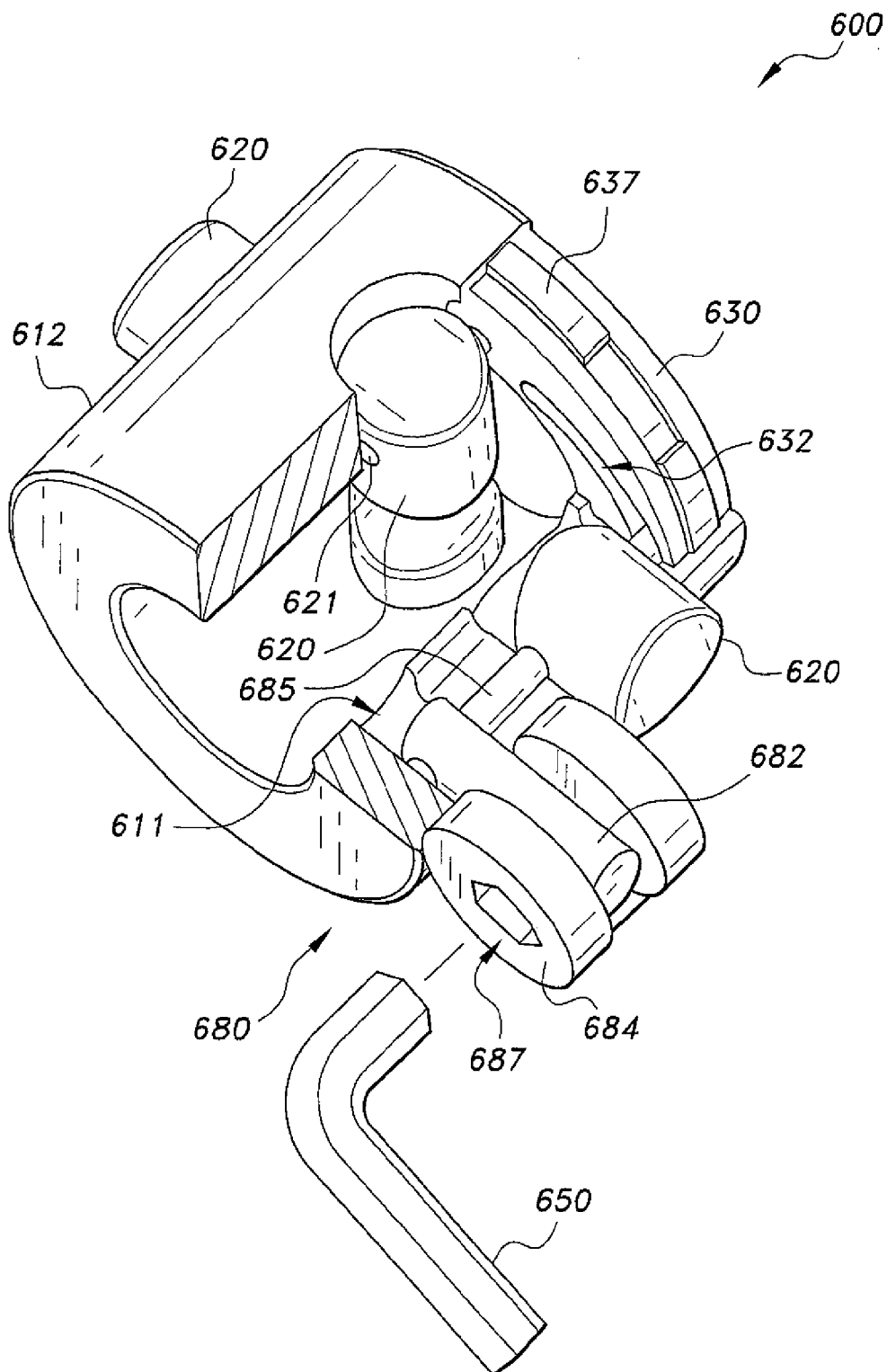




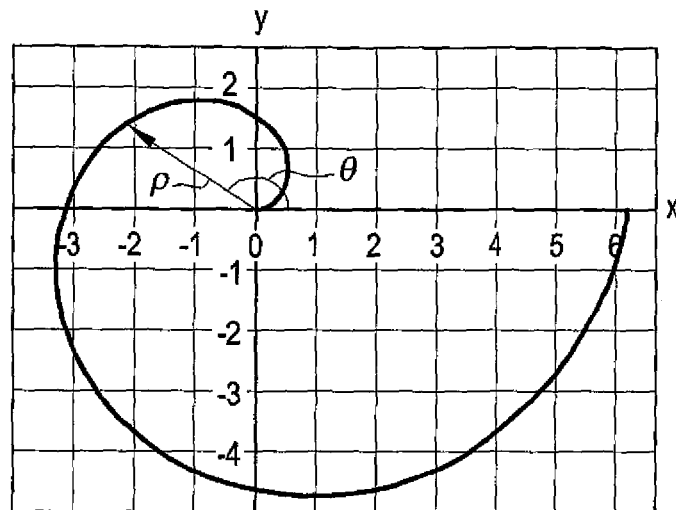
*Fig. 5*



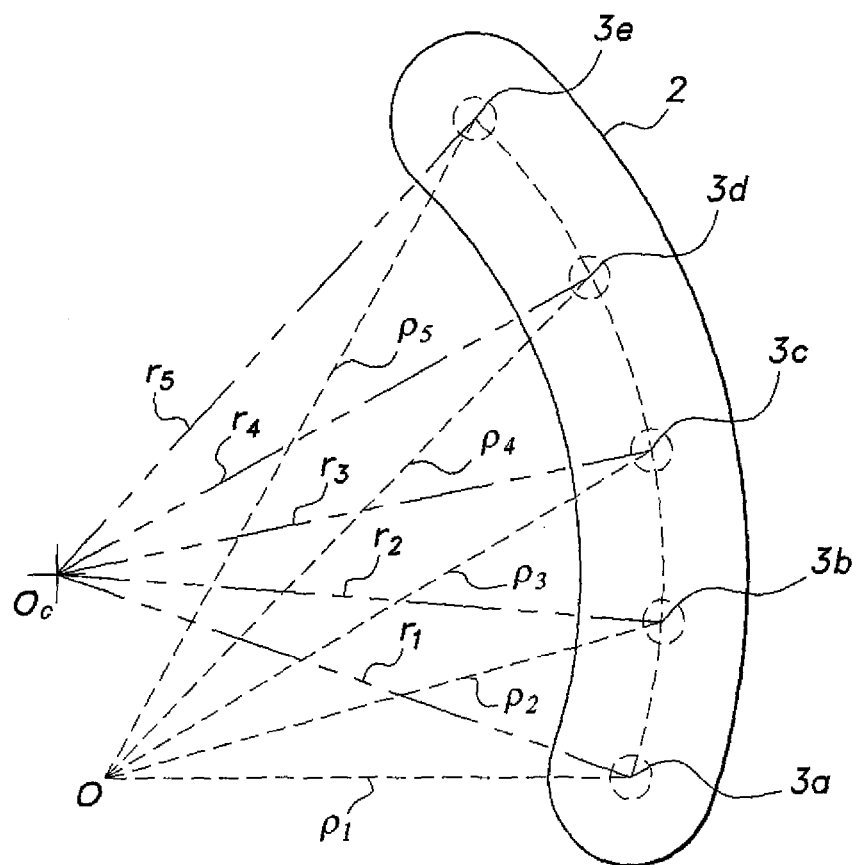
*Fig. 6*



*Fig. 7*



**Fig. 8A**



**Fig. 8B**

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**RADIALLY ENGAGING SYSTEM****CROSS-REFERENCE TO RELATED APPLICATIONS**

This is a continuation of my prior application Ser. No. 14/073,589, filed Nov. 6, 2013 now pending.

**BACKGROUND OF THE INVENTION****1. Field of the Invention**

The present invention relates to mechanical connectors, and particularly to various embodiments of a radially engaging system that utilize Archimedean spiral curves to facilitate selective extension and retraction of members and establish a positive connection thereby.

**2. Description of the Related Art**

In the myriad field of mechanical devices, many systems and sub-systems exist that facilitate extension or retraction of a connected member. Some of these types of devices include linear actuators, crank mechanisms, multiple linkage systems and the like. Some are powered, while others are manually operated. The complexity of these types of devices also varies widely, depending on the particular use and environment.

While many such systems exist, not many appear to have universal application that can convert rotation to linear motion and/or vice versa in an easy and efficient manner in the context of effort and operation, especially for connecting mechanical members together. One simplest example of this type of device is a screw fastener. Rotation of the screw head translates to linear movement of the screw via engaged threads, or by the thread on the screw biting into the structure being fastened thereby. While screw fasteners are generally ubiquitous in many different mechanical applications, they are not very easy to thread or unthread without the use of specialized tools, such as a screwdriver. At times, the screw fastener can jam, requiring much more than normal effort in using the fastener.

Another example includes mechanical locks, which often contain reciprocating members moved by a rotating mechanism, such as a rack and pinion system, crank system, and the like. The simplest locks usually do not require much effort to operate, but issues can arise from potential misuse of the keys or tool used to operate the lock, misalignment of components, or mechanical failure of components. More complex locks tend to increase such potential issues, and they are generally for specific use, e.g., vault locks.

Thus, a radially engaging system solving the aforementioned problems is desired.

**SUMMARY OF THE INVENTION**

The radially engaging system includes a housing having at least one guide channel formed thereon. At least one sliding member is slidably received in the guide channel to selectively extend or retract therein in order to connect and lock mechanical components together. The sliding member is provided with an elongate follower. A rotator is operatively mounted to the housing. The rotator includes at least one guide curve based upon an Archimedean spiral. The follower rides inside the guide curve. Selective rotation of the rotator converts the rotation into linear movement of the connected sliding member. Conversely, selective linear movement of the sliding member is converted into rotation of the rotator.

These and other features of the present invention will become readily apparent upon further review of the following specification and drawings.

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**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1A is a plan view of a radially engaging system according to the present invention.

FIG. 1B is an exploded perspective view of the radially engaging system of FIG. 1A.

FIG. 2 is a perspective view of another embodiment of a radially engaging system according to the present invention, shown with parts broken away and in section to show details thereof.

FIG. 3A is a perspective view of still another embodiment of a radially engaging system according to the present invention.

FIG. 3B is an exploded perspective view of the radially engaging system of FIG. 3A.

FIG. 3C is an elevation view in section of the radially engaging system of FIG. 3A, in which a pair of sliding members engage an inner wall of an inner housing.

FIG. 3D is another elevation view in section of the radially engaging system of FIG. 3A, in which another pair of sliding members engage holes in an outer housing.

FIG. 3E is a perspective view of the inner components for actuating the sliding members in the radially engaging system of FIG. 3A, shown with the housings removed.

FIG. 4A is a perspective view of yet another embodiment of a radially engaging system according to the present invention, shown with the housing broken away and partly in section.

FIG. 4B is an exploded perspective view of the radially engaging system of FIG. 4A.

FIG. 4C is a perspective view of the rotator for the radially engaging system of FIG. 4A.

FIG. 5 is a perspective view of a yet another embodiment of a radially engaging system according to the present invention, shown with components broken away and partly in section.

FIG. 6 is perspective view of yet another embodiment of a radially engaging system according to the present invention, shown with components broken away and partly in section.

FIG. 7 is a perspective view of a further embodiment of a radially engaging system according to the present invention, shown with components broken away and partly in section.

FIG. 8A is a graph of an Archimedean spiral.

FIG. 8B is a diagram illustrating construction of a guide curve for a radially engaging system according to the present invention based upon the principals of an Archimedean spiral.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The embodiments of a radially engaging system described herein provide various interlock devices utilizing Archimedean spiral configurations to facilitate selective extension and retraction of members to connect mechanical components or to facilitate selective extension and retraction of members to a mechanical component in a substantially effortless manner and with ease of operation. As best seen in the graph shown FIG. 8A, an Archimedean spiral is characterized by the mathematical formula:

$$\rho = a\theta$$

In the above formula,  $\rho$  equals the radius or radial vector from the point of origin O,  $a$  equals a constant, and  $\theta$  is the angle expressed in radians in polar coordinates. For any given constant  $a$ , there is a constant proportional relationship between the change in radial length and the change in angle.

In other words, any arbitrary point following the above formula will change in radial length at the same proportional constant rate as that of the angular rotation.

FIG. 8B shows an example of a curve 2 constructed with the principles of the above formula, the curve 2 defining the linear movement of a member, which will be further described in relation to the various embodiments described herein. In this example, it is desired to move a member a certain linear distance starting from an arbitrary initial point 3a to an end point 3e within a desired arc range, the desired linear movement in this example being 20 mm with an initial radius  $\rho_1$  of 50 mm within a 60° arc. The difference between the length of the initial radius  $\rho_1$  and the length of the end radius  $\rho_5$  equals the length of desired linear movement. The intermediate points 3b, 3c, 3d and the intermediate radial lengths  $\rho_2, \rho_3, \rho_4$  can be determined by dividing the arc range into equal increments, e.g., 15° intervals. Joining these points 3a, 3b, 3c, 3d, 3e provides a good approximation of the shape of the desired curve 2. Increasing the increments will result in a more accurate curve 2.

Additionally, the above curve 2 can also be approximated by a simple circular curve. As shown in FIG. 8B, the curve 2 can have the properties of a simple circular curve where the axis or point of origin  $O_C$  is offset from the original point of origin O. The radii  $r_1, r_2, r_3, r_4, r_5$  to each respective point 3a, 3b, 3c, 3d, 3e on the curve from the offset point of origin  $O_C$  are approximately equal to each other. This results in an approximate circular curve 2 that spans approximately 65.6° arc, where the average radius in the above example is about 57.6 mm. Thus, it can be seen that an Archimedean spiral can also be expressed by a circular curve.

Using the above concepts, it has been found that a relatively smooth and effortless translational curve can be constructed, especially for radially engaging systems, to connect or interlock mechanical components. FIGS. 1A and 1B show a first embodiment of a radially engaging system 10.

In this embodiment, the radially engaging system 10 includes a housing 12 defining a central throughbore 11 and a plurality of guide channels or grooves 14, 16, 18 formed therein, i.e. a first guide channel 14, a second guide channel 16, and a third guide channel 18. The housing 12 is substantially square in shape, but it is to be understood that the housing 12 can be provided with a variety of different shapes. Sliding members, i.e., a first sliding member 20, a second sliding member 22, and a third sliding member 24, are slidably disposed in corresponding guide channels 14, 16, 18. The guide channels 14, 16, 18 guide and confine sliding or reciprocating movement of the respective sliding members 20, 22, 24. In this embodiment, each sliding member 20, 22, 24 is constructed with a different cross-sectional shape. For example, the first sliding member 20 is provided as an elongate cylindrical post, the second sliding member 22 is provided as an elongate substantially square post, and the third sliding member 24 is constructed as an elongate hexagonal post.

A rotator 30 in the form of a rotating disk is operatively connected to each sliding member 20, 22, 24 to facilitate selective extension or retraction of the sliding members 20, 22, 24 with respect to the housing 12. Each sliding member 20, 22, 24 includes a respective follower extending orthogonally from near the bottom of the corresponding sliding member 20, 22, 24, i.e., a first follower 21 for the first sliding member 20, a second follower 23 for the second sliding member 22, and a third follower 25 for the third sliding member 24. Each follower 21, 23, 25 is preferably configured as a small cylindrical post fixed to the respective sliding member 20, 22, 24. Alternatively, each follower 21, 23, 25 can

be configured as a small roller rotatably mounted to the corresponding sliding member 20, 22, 24.

The rotator 30 includes a plurality of guide curves 32, 34, 36 formed therein. Each guide curve 32, 34, 36 is configured to receive one of the followers 21, 23, 25 therein. Each guide curve 32, 34, 36 is formed in accordance with (has the curvature of) an Archimedean spiral. Upon rotation of the rotator 30, each guide curve 32, 34, 36 imparts a linear translation movement to the respective sliding member 20, 22, 24 connected thereto. The rotator 30 can include a socket or recess 31 for selective insertion of a tool in order to selectively rotate the rotator 30. Depending upon user preference and requirements, each of the guide curves 32, 34, 36 can be of the same shape except for their angular disposition around the axis of the rotator 30, which results in the sliding members 20, 22, 24 moving the same travel distance from one end of the curve to the other end. However, the Archimedean spiral permits a wide range of distances for a given rotational arc.

For example, in this embodiment, the first guide curve 32 and the second guide curve 34 are substantially the same shape and dimension. Thus, the corresponding first sliding member 20 and the second sliding member 22 both travel the same distance. In this embodiment, the given arc rotation is 70° and the first and second sliding members 20, 22 travel about 12 mm as they are pushed or pulled by the rotation of the respective curve from one end of the curve to the other end. In contrast, the third guide curve 36 provides 8 mm of travel distance for the third sliding member 24, but only within a 50° rotation arc. The actual potential travel distance of the third sliding member 24 would be farther than 8 mm if the third guide curve 36 were formed so that the spiral shape thereof continued to extend the additional 20°. However, design constraints, such as the dimensions of the rotator 30 and the space provided thereby, or an intentional inclusion of a feature, can prohibit fully extending the third guide curve 36 through the full 70° degree arc. In order to maintain movement of all three sliding members 20, 22, 24 within the given arc rotation, the third guide curve 36 includes an auxiliary section 37. The auxiliary section 37 is preferably concentric with the diameter of the rotator 30 and forms an arc segment that extends the remainder of the given arc rotation, i.e., 20°. This auxiliary section 37 also performs a self-locking function by preventing movement of the third sliding member 24 unless the rotator has been rotated back to the beginning of the auxiliary section 37.

The radially engaging system 10 can be utilized in various different environments, such as for assembling components. Each sliding member 20, 22, 24 can be designated to a specific assembly part having a correspondingly shaped reception hole or bore and be connected thereby. This insures that there is no confusion with respect to placement and connection of various assembly parts. Another use includes locking functions where the different shapes of the sliding members 20, 22, 24 can be used to provide a proprietary or non-standard lock, which can help prevent undesirable tampering.

Another embodiment of a radially engaging system is shown in FIG. 2. In this embodiment, the radially engaging system 100 includes a locking system incorporated therein to lock sliding members in either their extended or retracted positions.

As shown in the drawing, the radially engaging system 100 includes a substantially hollow, cylindrical housing 112 having a plurality of guide channels or bores 114 angularly spaced around the cylindrical housing 112. The guide channels 114 radially extend into the wall of the cylindrical housing 112 but not completely through the wall. A sliding member 120 is slidably received inside each guide channel 114, the

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guide channels **114** confining and defining the path or reciprocal movement of the sliding members **120**. Each sliding member **120** includes an elongate follower **121** extending orthogonally from near the top of the respective sliding member **120**. An elongate guide slot **115** is formed in the wall and communicates with a respective guide channel **114**. Each guide slot **115** permits a respective follower **121** to pass through and ride therein. Each guide slot **115** is preferably narrower in thickness compared to the length of the follower **121** to permit engagement of the follower **121** with a rotator **130**.

One end of the housing **112** includes a recess **113** shaped and sized to receive the rotator **130**. In this embodiment, the rotator **130** is constructed as an annular disc having at least one pair of keyholes **138** extending axially through the thickness of the rotator **130**. One side of the rotator **130** is provided with a plurality of guide curves or grooves **132** configured to operatively receive one of the followers **121** in each guide groove **132**. The rotator **130** can also include an annular groove **136** around the outer circumference thereof for placement of a clutch ring (not shown) to secure the mounting of the rotator **130** onto the housing **112**. An example of such a clutch ring **237** is shown FIG. **3E** in another embodiment.

The radially engaging system **100** also includes a locking mechanism **140** for selectively locking the rotator **130** in positions in which the corresponding sliding members **120** are either fully retracted or extended. The locking mechanism **140** includes an elongate lock post **142** biased into an extended, locked position by a spring **144**. Both the lock post **142** and the spring **144** are disposed within a lock recess **143** near the other end of the housing **112**. The top or upper end of the lock post **142** can include an engagement head **146**, which serves as a component for interaction with a key **150**, and as an abutment preventing relative rotation of the rotator **130** in the normal, extended and locked position. The lock post **142** is preferably larger in diameter than the diameter of the keyhole **138**. The diameter of the engagement member **146** is preferably small enough to fit inside the keyhole **138**. By this construction, the locking post **142** axially abuts the side of the rotator **130** in the normal locked position, while the engagement head **146** resides inside the keyhole **138**, effectively locking the rotator **130** in position.

In order to operate the locking mechanism **140**, the radially engaging system **100** includes the key **150**. The key **150** can be a wrench having an elongate handle **152** and a pair of elongate posts or key members **153**, **154** extending orthogonally therefrom, i.e., a first key member **153** and a second key member **154**. Each key member **153**, **154** is configured to fit through the keyhole **138**. At least one of the key members **153**, **154** is constructed to interact with the locking post **142**. In this embodiment, the second key member **154** can include an engagement head **155** at the distal end thereof, which effectively results in the second key member **154** being longer than the first key member **153**. Alternatively, the key member **154** can be constructed to be longer than the key member **153** without an engagement head **155**. In use, the user inserts the key **150** into the keyholes **138**, and the second key member **154** presses against the bias of the engagement head **146** via the engagement head **155** until the engagement member **146** is free from the keyhole **138**. At this point, the user can turn the key **150**, thereby rotating the rotator **130**. In this embodiment, the locking mechanism **140** automatically engages the keyhole **138** via the spring **144** when the rotator **130** has been rotated to the fully retracted position of the sliding members **120**, i.e., retracted with respect to the axis of the housing **112**.

Like the previous radially engaging system **10**, the radially engaging system **100** facilitates a variety of uses. For

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example, the radially engaging system **100** can be used to clamp onto a mechanical component inserted through the housing **112**. The clamping occurs when the sliding members **120** are retracted towards the axis of the housing **112**. In another example, separate mechanical components having corresponding holes dimensioned and configured to fit the sliding members **120** can be selectively connected together by the same type of action.

Another embodiment of a radially engaging system **200** is shown in FIGS. **3A-3D**. In this embodiment, the radially engaging system **200** facilitates inner and outer connection or locking of mechanical components.

As best seen in FIGS. **3A** and **3B**, the radially engaging system **200** includes a substantially hollow, cylindrical housing **212** having at least two pairs of guide channels or bores **214**, **216** angularly spaced around the cylindrical housing **212**. A pair of first guide channels **214** is disposed at diametrically opposed positions on the housing **212**. A pair of second guide channels **216** is also disposed at diametrically opposed positions on the housing **212** orthogonal to the first guide channels **214**. The guide channels **214**, **216** radially extend through the wall of the cylindrical housing **212**. A first sliding member **220** is slidably received inside each first guide channel **214**, and a second sliding member **222** is slidably received inside each of the second guide channels **216**. The guide channels **214**, **216** confine and define the path or reciprocable movement of the sliding members **220**, **222**. Each sliding member **320** includes an elongate follower **221** extending orthogonally from near the top of the respective first sliding member **220**, and each second sliding member **222** includes an elongate follower **223** extending orthogonally from near the bottom of the respective sliding member **222**.

One end of the housing **212** includes a recess (not shown but substantially the same as the recess **113** in the previous embodiment) dimensioned and configured to receive a rotator **230**. In this embodiment, the rotator **230** is constructed as an annular disc having at least one pair of keyholes **238** extending through the thickness of the rotator **230**. As best seen in FIG. **3E**, one face of the rotator **230** is provided with at least two pairs of guide curves or grooves **232**, **234**. A pair of first guide grooves **232** is configured to operatively receive the followers **221** of the first sliding members **220**. Similarly, a pair of second guide grooves **234** is configured to operatively receive the followers **223** of the second sliding members **222**. The rotator **230** also includes an annular groove **236** around the outer surface thereof for placement of a clutch ring **237** to secure the mounting of the rotator **230** onto the housing **212**.

For a given rotational arc of the rotator **230**, each first guide groove **232** facilitates selective retraction and extension of the respective sliding members **220** in order to engage and lock a component inside the housing **212**. In this instance, the component is an elongate shaft or rod **270** having a throughbore **272** extending perpendicularly therethrough and aligned in communication with the first guide channels **214** when assembled. Each first guide groove **232** spirals in the same polar coordinate direction, except the grooves **232** are disposed **180°** apart.

Conversely, for a given rotational arc of the rotator **230**, each second guide groove **234** facilitates selective extension and retraction of the respective sliding members **222** in order to engage and lock a component outside the housing **212**. In this instance, the component is an outer hollow cylindrical housing **260** having a central opening **263** for selective insertion of the housing **212**. A pair of diametrically opposed throughbores **262** is formed on the outer housing **260** and aligned in communication with the second guide channels **216** when assembled. Each second guide groove **234** spirals

in the same polar coordinate direction, except the grooves **234** are disposed 180° apart. Moreover, the direction of spiral is opposite that of the first guide grooves **232**. In this embodiment, each sliding member **220**, **222** is preferably provided with curved ends to better conform with the circular shapes of the shaft **270** and the outer housing **260**.

The radially engaging system **200** can also include a locking mechanism **240**. In this embodiment, the locking mechanism includes a pair of elongate lock posts **242** biased into an extended, locked position by a respective spring **244**, the lock posts **242** being the same construction as the previously described lock posts **142**. The locking mechanism **240** operates in substantially the same manner as the locking mechanism **140** and utilizes a similar key (not shown) as the previously described key **150**, except that the key would include an engagement head on both key members or be of equal length.

In use, selective rotation of the rotator **230** by a predetermined rotation arc in one direction by a key causes the first sliding members **220** to retract into the throughbore **272** on the shaft **270**. At the same time, the second sliding members **222** extend into the throughbores **262** on the outer housing **260**. Rotation of the rotator **230** in the opposite direction reverses the above process. The locking mechanism **240** can be constructed to lock the rotator **230** in either or both rotated positions. Thus, the radially engaging system **200** facilitates simultaneous connection or locking of inner and outer mechanical components. It is to be recognized that while the above has been described with reference to various pairs of sliding members **220**, **222** and their corresponding guide curves or groove **232**, **234**, any of the embodiments described herein can utilize any number of sliding members and guide curves at various positions within and about the housing to facilitate the selective retraction and extension, depending on the particular interlocking connection desired.

Yet another embodiment of a radially engaging system is shown in FIGS. 4A-4C. In this embodiment, the radially engaging system **300** can be used to lock joints and the like at select positions and includes an alternative locking mechanism.

As best seen in FIGS. 4A and 4B, the radially engaging system **300** includes a substantially hollow, cylindrical housing **312** having a plurality of guide channels or bores **314** angularly spaced around the cylindrical housing **312**. The guide channels **314** radially extend through the wall of the cylindrical housing **312**. A sliding member **320** is slidably received inside each guide channel **314**, the guide channels **314** confining and defining the path or reciprocable movement of the sliding members **320**. Each sliding member **320** includes an elongate follower **321** extending orthogonally from near the bottom of the respective sliding member **320**. An elongate guide slot **315** is formed in the wall and communicates with a respective guide channel **314**. Each guide slot **315** permits a respective follower **321** to pass through and ride therein. In this embodiment, the radially engaging system **300** is provided with six sliding members **320**, which provide a plurality of points of locking engagement.

One end of the housing **312** includes an annular groove **317** for receiving a clutch ring **319** thereon. The above permits selective and secure mounting of the radially engaging system **300** into a correspondingly shaped recess or receptacle. A circular rotator **330** is disposed on the opposite end of the housing **312**. One side of the rotator **330** is provided with a plurality of guide curves or grooves **332** configured to operatively receive one of the followers **321** in each guide groove **332**.

The radially engaging system **300** is also provided with an outer housing, casing or cap **360** constructed to enclose and

cover the housing **312** and the rotator **330**. The outer housing **360** includes a central bore **363** for receiving a component of the locking mechanism to be described herein. A plurality of outer bores or holes **362** are formed around the circumferential wall of the outer housing **360**. The outer bores **362** are equal in number to the number of sliding members **320**. When assembled, the sliding members **320** extend into the respective outer bores **362** to secure the outer housing **360**.

In order to selectively rotate the rotator **330** and lock the relative position thereof, the radially engaging system **330** also includes a locking mechanism **340**. The locking mechanism **340** includes an elongate lock post **342** mounted to the central bore **363**. A socket **347** is formed on one end of the lock post **342**, and an engagement head **346** is formed on the opposite end. The socket **347** is configured to selectively receive a tool or key, such as a hex wrench. As best seen in FIGS. 4A and 4C, an elongate groove **331** is formed on the opposite face of the rotator **330**. The elongate groove **331** is configured to receive a leaf spring **343**. The leaf spring **343** includes an elongate engagement slot **345** dimensioned and configured to receive the engagement head **346**. In this embodiment, both the engagement head **346** and the engagement slot **345** are rectangular in shape.

In use, the leaf spring **343** is normally uncompressed, and the engagement head **346** is received in the engagement slot **345**, which effectively locks the rotator **330** in position. In order to rotate the rotator **330**, the user uses a tool or key via the socket **347** to rotate the locking post **342** inwards, compressing or flattening the leaf spring **343** within the elongate groove **331**. Once flattened to a point, continuous turning of the locking post **342** drives rotation of the rotator **330** in order to extend or retract the sliding members **320**. Reversal of the above process facilitates the opposite.

Yet another embodiment of a radially engaging system is shown in FIG. 5. In this embodiment, the radially engaging system **400** can be used to simultaneously connect or lock mechanical components in multiple positions.

As shown in the drawing, the radially engaging system **400** includes a substantially hollow housing **412** having a plurality of sub-housings **411** radiating therefrom. In this embodiment, four of the sub-housings extend radially in orthogonal directions, while the last sub-housing extends from the back of the housing **412**. Each sub-housing **411** is preferably shaped as a hollow cylindrical post and includes a guide channel **414** extending orthogonally through the sub-housing **411**. A pair of sliding members **420** is slidably received inside each guide channel **414**, the guide channels **414** confining and defining the path or reciprocable movement of the sliding members **420**. Each sliding member **420** includes an elongate follower **421** extending orthogonally from near the bottom of the respective sliding member **420**.

A circular rotator **430** is disposed inside each sub-housing **411**. One side of the rotator **430** is provided with a plurality of guide curves or grooves **432** configured to operatively receive one of the followers **421** in each guide groove **432**. The opposite side of the rotator **430** is provided with an integrated bevel gear **431**. When assembled, all five of the rotators **430** are meshed together via the respective bevel gears **431**.

In order to rotate the rotators **430** simultaneously, the radially engaging system **400** includes an actuator **442** mounted to the front of the housing **412**. In this embodiment, the actuator **442** is constructed as a frustoconical member having a socket **447** to selectively receive a key or tool on one side and an integrated bevel gear **446** on the opposite side. The bevel gear **446** meshes with adjacent bevel gears **531**.

In operation, the user inserts a key or tool, such as a hex wrench, into the socket **447** and rotates the actuator **442** in a



selected direction. Rotation of the actuator **442** simultaneously rotates all the rotators **430** due to the intermeshing of all the bevel gears **431**, **446**. Consequently, all the sliding members **420** extend or retract, depending on the rotation direction of the actuator **442**.

Yet further embodiments of radially engaging system are disclosed in FIGS. **6** and **7**. In these embodiments, radial movement of sliding members is not facilitated by positive rotation of a rotator. Instead, the radial movement is facilitated by positive actuation of at least one of the sliding members, i.e., a conversion of linear motion to rotary motion.

As best seen in FIG. **6**, the radially engaging system **500** is substantially the same in construction as many of the previously described embodiments. The radially engaging system **500** includes a substantially hollow, cylindrical housing **512**, a plurality of guide channels or bores **514**, a plurality of sliding members **520** slidably received inside each guide channel **514**, an elongate follower **521** on all except at least one of the sliding members **520**, an annular rotator **530**, a plurality of guide curves **532** and a clutch ring **537** for securely mounting the rotator **530** to the housing **512**.

In this embodiment, the radially engaging system **500** includes a linear actuator **580**. The linear actuator **580** includes a drive post, shaft or rod **582** rotatably mounted inside a boss **511** extending radially from a side of the housing **512**. A socket **587** is formed on one end of the drive shaft **582** to selectively receive a tool or key. The opposite end includes an annular stabilizing groove **583**, which interacts with a stabilizing pin **581** inserted through one end of the housing **512**. The stabilizing pin **581** rides inside the stabilizing groove **583** and prevents axial movement of the drive shaft **582** with respect to the boss **511** during operation; thus stabilizing and maintaining relative position of the drive shaft **582**.

An elongate threaded bolt **584** extends axially from the drive shaft **582** and engages a connecting member **586** via the threads thereon. The connecting member **586**, in turn, is connected to an elongate drive follower **585** extending through one of the sliding members **520** and into a respective guide curve **532**, the drive follower **585** being disposed orthogonal to the threaded bolt **584**.

In operation, instead of rotating the rotator **530**, the user rotates the drive shaft **582** with a key or tool inserted in the socket **587**. Rotation of the drive shaft **682** rotates the threaded bolt **584**, which pushes or pulls the connecting member **586**, depending on the direction of rotation. Pushing or pulling of the connecting member **586** forces the connected sliding member **520** to retract or extend, respectively. Due to the drive follower **585** connection to one of the guide curves **532**, the linear movement of the drive follower **585** forces the rotator **530** to rotate, thereby facilitating concurrent extension and retraction of the remaining sliding members **520**. In this embodiment, the guide curve **532** is driven by the drive follower **585**. The Archimedian spiral principal in constructing the guide curve **532** provides a guide curve wherein the transition from linear to rotary motion can be accomplished with minimal effort due to the curve being smooth and constant. Such a constant curve results in the same magnitude of force being exerted throughout the predefined rotational arc, i.e., whatever force is required to linearly move the drive follower **585** along the guide curve **532** would be the same at any point on the curve.

As best seen in FIG. **7**, the radially engaging system **600** is substantially the same in construction as the radially engaging system **500**. In that regard, the radially engaging system **600** includes a substantially hollow, cylindrical housing **612**, a plurality of guide channels or bores **614**, a plurality of

sliding members **620** slidably received inside each guide channel **614**, an elongate follower **621** on all except at least one of the sliding members **620**, an annular rotator **630**, a plurality of guide curves **632** and a clutch ring **637** for securely mounting the rotator **630** to the housing **612**.

In this embodiment, the radially engaging member **600** includes a linear actuator **680**. The linear actuator **680** includes a drive post, shaft or rod **682** rotatably mounted to an eccentric cam **684** at one end. The eccentric cam **684** is disposed on a side of the housing **612**, and the drive rod **682** extends radially into the housing **612** through a side bore **611**. The eccentric cam **684** is constructed as cylindrical bracket straddling the connected end of the drive rod **682**. The pivot or rotational axis for the drive rod **682** is offset from the axis of the cylindrical bracket. A socket **687** is formed on one end of the eccentric cam **684** to selectively receive a tool or key **650**. In this instance, the tool **650** can be a hex wrench. The other end of the drive rod **682** is connected to an elongate drive follower **685** extending through one of the sliding members **620** and into a respective guide curve **632**, the drive follower **685** being disposed orthogonal to the threaded drive rod **682**.

In operation, instead of rotating the rotator **630**, the user rotates the eccentric cam **684** with the tool **650**. Rotation of the eccentric cam **684** linearly pushes or pulls the drive rod **682**, depending on the direction of rotation. The drive rod **682** is confined to reciprocate within the side bore **611**. Pushing or pulling of the connecting member drive rod **682** forces the connected sliding member **620** to retract or extend, respectively. Due to the drive follower **685** connection to one of the guide curves **632**, the linear movement of the drive follower **685** forces the rotator **630** to rotate, thereby facilitating concurrent extension and retraction of the remaining sliding members **620**. Thus, the function and operation of the radially engaging system **600** is substantially the same as that of the radially engaging system **600**, except that the driver is an eccentric cam instead of a screw-type driver.

In all the embodiments described above, the radially engaging systems **10**, **100**, **300**, **300**, **400**, **500**, **600** incorporate a rotator having at least one guide curve based upon an Archimedian spiral, a sliding member and follower slidably connected to the guide curve, and a guide channel for confined reciprocal movement of the sliding member. The principals of the Archimedian spiral permit relatively smooth extension and retraction of the sliding members, due in part to the numerous user-defined guide curve configurations where the relative angular disposition of the guide curve, i.e., the general direction that the guide curve extends with respect to the axis of rotation, can be steep or shallow, yet positioned so that the effort required to move the sliding members, either through rotation to linear translation or vice versa, is kept to a desirable minimum.

It is to be noted that the radially engaging system **10**, **100**, **200**, **300**, **400**, **500**, **600** encompasses a wide variety of alternatives. For example, any of the above systems can be constructed from various materials, such as wood, plastic, steel, composites, and combinations thereof. Some or all of the components of the radially engaging system can be provided with differentiating colors and/or indicia. The descriptions of the use of the various embodiments should not be construed as being limited thereto. The engaging system **10**, **100**, **200**, **300**, **400**, **500**, **600** can be used in any situation requiring selective locked connection of mechanical components. Additionally, the number of sliding members and their orientation, the particular configuration and orientation of the guide curves, and the shape of the sliding members and the corresponding guide channels can be varied according to the desires and requirements of the user.

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It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

We claim:

1. A radially engaging system, comprising:

a housing having at least one guide channel formed therein;  
at least one sliding member slidably disposed in a respective guide channel to reciprocate therein;

a follower extending orthogonally from each sliding member;

at least one rotator rotatably connected to the housing, the at least one rotator having at least one guide curve formed therein, the at least one guide curve being configured as an Archimedian spiral, the follower being received in the at least one guide curve and extending away from an axis of rotation of the rotator, the at least one guide curve defining a predefined travel distance for the at least one sliding member;

a rotating mechanism for selectively rotating the rotator to selectively extend or retract the at least one sliding member into and out of locking engagement with at least one mechanical component;

wherein a rate of linear movement of the at least one sliding member is proportionately constant with a rate of rotation of the rotator;

wherein the housing comprises an elongate, substantially hollow cylindrical housing;

wherein the at least one sliding member comprises a plurality of sliding members spaced around the cylindrical housing;

wherein the at least one rotator has at least one pair of keyholes angularly spaced therein;

the rotating mechanism including a key having an elongate handle and a pair of spaced key members extending orthogonally from the elongate handle, each of the key members being selectively insertable into one of the pair of keyholes to engage the at least one rotator and selectively turn the key in order to rotate the at least one rotator;

means for locking the rotator in selected positions, the means for locking having:

at least one lock recess formed inside the cylindrical housing;

at least one spring disposed in the lock recess;

at least one lock post abutting the at least one spring at one end, the at least one lock post having a diameter larger than the keyholes, the at least one lock post being normally biased by the at least one spring to abut against the one of the keyholes; and

an engagement head formed on an opposite end of the at least one lock post, the engagement head having a diameter smaller than the diameter of the at least one lock post, the engagement head being normally engaged inside the one of the keyholes to prevent rotation of the at least one rotator;

wherein one of the key members has a length greater than the length of the other key member, the longer length extending the one of the key members to push the engagement head against the bias of the at least one spring upon insertion of the key into the keyholes to free engagement of the engagement head with the one of the keyholes to thereby unlock and rotate the at least one rotator.

2. A radially engaging system, comprising:

a housing having at least one guide channel formed therein;

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wherein the housing includes an elongate, substantially hollow cylindrical housing;

at least one sliding member slidably disposed in a respective guide channel to reciprocate therein;

wherein the at least one sliding member includes a plurality of sliding members spaced around the cylindrical housing;

a follower extending orthogonally from each sliding member;

at least one rotator rotatably connected to the housing, the at least one rotator having at least one guide curve formed therein, the at least one guide curve being configured as an Archimedian spiral, the follower being received in the at least one guide curve and extending away from an axis of rotation of the rotator, the at least one guide curve defining a predefined travel distance for the at least one sliding member;

wherein the at least one rotator has at least one pair of keyholes angularly spaced therein;

a rotating mechanism for selectively rotating the rotator to selectively extend or retract the at least one sliding member into and out of locking engagement with at least one mechanical component;

the rotating mechanism including a key having an elongate handle and a pair of spaced key members extending orthogonally from the elongate handle, each of the key members being selectively insertable into one of the pair of keyholes to engage the at least one rotator and selectively turn the key in order to rotate the at least one rotator;

wherein a rate of linear movement of the at least one sliding member is proportionately constant with a rate of rotation of the rotator;

an elongate shaft insertably mounted inside the cylindrical housing, the elongate shaft having a throughbore extending transversely therethrough, the throughbore being aligned and communicating with a pair of diametrically opposed first guide channels in the cylindrical housing; and

a hollow outer cylindrical housing having a central opening to selectively receive the cylindrical housing and a pair of diametrically opposed throughbores formed thereon, the throughbores of the outer cylindrical housing being aligned and communicating with a pair of second guide channels on the cylindrical housing.

3. The radially engaging system according to claim 2, wherein the at least one rotator comprises:

an annular rotator having a pair of first guide curves and a pair of second guide curves angularly spaced about the annular rotator, the first guide curves spiraling in the same direction with respect to each other, the second guide curves spiraling in the same direction with respect to each other and in a direction of spiral opposite to the direction of spiral of the first guide curves;

wherein upon rotation of the annular rotator about a given rotation arc, the first guide curves force a pair of first sliding members to retract into the throughbore of the elongate shaft and the second guide curves force a pair of second sliding members to extend into the throughbores of the outer cylindrical bores to thereby simultaneously connect and lock both the elongate shaft and the outer cylindrical housing.

4. The radially engaging system according to claim 3, further comprising a locking mechanism for locking the annular rotator in selected positions, the locking mechanism having:

a pair of springs;

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a pair of lock posts, each of the lock posts abutting a respective spring at one end, each of the lock posts having a diameter larger than the keyholes, each of the lock posts being normally biased by the respective spring to abut against the respective keyhole; and  
 5 an engagement head formed on an opposite end of each of the lock posts, the engagement head having a diameter smaller than the diameter of the lock post, the engagement head normally being engaged inside a respective keyhole to prevent rotation of the annular rotator;  
 10 wherein selective insertion of the key members through the keyholes pushes the engagement heads against the bias of the spring to free engagement of the engagement heads with the keyholes to unlock and rotate the annular rotator.  
 15 5. A radially engaging system, comprising:  
 a housing having at least one guide channel formed therein; wherein the housing includes an elongate, substantially hollow cylindrical housing;  
 at least one sliding member slidably disposed in a respective guide channel to reciprocate therein;  
 wherein the at least one sliding member includes a plurality of sliding members spaced around the cylindrical housing;  
 a follower extending orthogonally from each sliding member;  
 25 at least one rotator rotatably connected to the housing, the at least one rotator having at least one guide curve formed therein, the at least one guide curve being configured as an Archimedian spiral, the follower being received in the at least one guide curve and extending away from an axis of rotation of the rotator, the at least one guide curve defining a predefined travel distance for the at least one sliding member; and  
 30 a rotating mechanism for selectively rotating the rotator to selectively extend or retract the at least one sliding mem-

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ber into and out of locking engagement with at least one mechanical component, the rotating mechanism consisting of an outer housing substantially covering the cylindrical housing and the at least one rotator, the outer housing having a central bore and at least one outer bore formed around the outer housing, the at least one outer bore being aligned with the at least one guide channel, each the sliding member extending into the at least one outer bore to secure the outer housing; and  
 a locking mechanism disposed between the at least one rotator and the outer housing to lock rotated positions of the at least one rotator;  
 wherein a rate of linear movement of the at least one sliding member is proportionately constant with a rate of rotation of the rotator.  
 6. The radially engaging system according to claim 5, wherein the locking mechanism comprises:  
 an elongate groove formed on a side of the at least one rotator;  
 a leaf spring disposed in the elongate groove, the leaf spring having an elongate engagement slot formed therein; and  
 a lock post rotatably mounted in the central bore of the outer housing, the lock post having a socket at one end adapted to selectively receive a tool key therein and an elongate engagement head formed on the opposite end of the lock post, the engagement head being insertably mounted into the engagement slot, the leaf spring normally biasing the lock post against an interior of the outer housing and locking the at least one rotator;  
 wherein selective rotation of the lock post presses the leaf spring into the elongate groove, releasing the lock to rotate the at least one rotator in a desired direction.

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